Characterization of Conservation agricultural (CA) to control water erosion and to preserve soil water

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INTRODUCTION

Annual rainfall variability has been noticed in the Lake Alaotra region of Madagascar during thirty years (1997 – 2007) (Razakavololona, 2011). This variability was a major factor limiting upland agriculture (Penot *et al.*, 2010). Firstly, excess rainfall causes in slope water erosion and nutrient losses (Ratsivalaka, 2007, Razafindramanana, 2011) and contributes lake's siltation. Then, the area of soil cultivable and soil fertility tend to decrease. Secondly, under conditions of water scarcity, the water shortage is a real problem in the upland agriculture. In fact, the most important for famers is to improve water management system. Conservation agricultural (CA) is proposed to optimize the benefits of water distribution system. The previous research conducted in experimental in the same region during two years showed positive effect of CA to control water erosion. However, the effect of cover rates in controlling water erosion and soil moisture was not considered. So, this work supplements this previous research. The main objective is to compare the effects of different cover rates to control water erosion and to improve soil water storage.

MATERIALS AND METHODS

This study was conducted in the Lake Alaotra region of Madagascar. It was undertaken on research station, under natural rainfall during the rainy seasons. The area has a tropical altitude climate. Data collected for ten years (2002 – 2012) on meteorology station of Ambohitisilaozana – Ambatondrazaka showed that the mean annual precipitation and temperature are respectively 1091 mm and 20.7°C. The soil is classified as ferralsols (Razafimbelo *et al*., 2010). We compared three levels of cover rates by *Stylosanthes guinensis* in the upland rice fields: 0, 40% or 40 kg DM ha^{-1}, 100% or 100 kg DM ha^{-1}. These cover rates were compared in two slopes: 9% and 27%.

Three erosion plots (1m x 1m) were enclosed on each field and they were inserted to a soil depth of 10 cm, to monitor runoff and soil losses. The plots were installed in the direction of the slope with an outlet system for collecting runoff water and solid matter. Runoff was measured at each rainfall event, so runoff depth (mm) was calculated by the ratio of runoff volume (l) by area of runoff erosion plot (m^2). Soil losses were estimated by taking a subsample of 1.5 l per plot from the runoff suspension in the containers. Then, these subsamples were filtered to retain solid particles. The mass of solid particles was determined after oven drying the filter solid particles' contained at 105°C during 24h, so annual soil losses ($g.m^{-2}$ an^{-1}) were calculated for each treatment.

Time domain reflectrometry (TDR) was used to determine soil moisture, eighteen TDR probes were installed horizontally. Measurement was carried out every eight days, from the sowing date to the harvest, on different depths (0 – 15 cm; 15 – 25 cm; 25 – 35 cm; 35 – 50 cm; and 50 – 70 cm) to have the amount of soil moisture on % of volume. Soil water storage was calculated by multiplying the soil moisture (% of volume) by the depth (mm) for each treatment.

RESULTS AND DISCUSSION

Water runoff and soil losses

Firstly, as we can see in Figure 1, with the low slope, the amount of total annual runoff was two times decreased on field partially and totally covered compared to the runoff measured on no cover field. Significant difference was observed between 0% and 40 % or 100% cover rates, whereas between 40% and 100% cover rates, the difference was not significant. Similar pattern was observed with the high slope but the difference between the quantities of runoff on cover and no cover fields was more pronounced.

Secondly, Figure 2 shows that on the low slope, soil losses were reduced significantly by 33% and 67% on fields covered respectively of 40% and 100%. Similar observation was noticed on the high slope (0.8 and 1 t ha^{-1} in soil cover against 6 t ha^{-1} in soil no cover).

These results confirm the positive effect of mulch in controlling water erosion (Husson *et al*., 2008). The mulch protects the soil surface against the splash effect of raindrops, delays the start of the runoff and reduces its intensity (Summer *et al*., 1992; Scopel *et al*., 2004). Our erosion rate is lower compared to the values founded by others authors (*e.g.* Scopel *et al.*, 2005 in Brazil, Razafindramanana, 2011 in the highlands of Madagascar,).

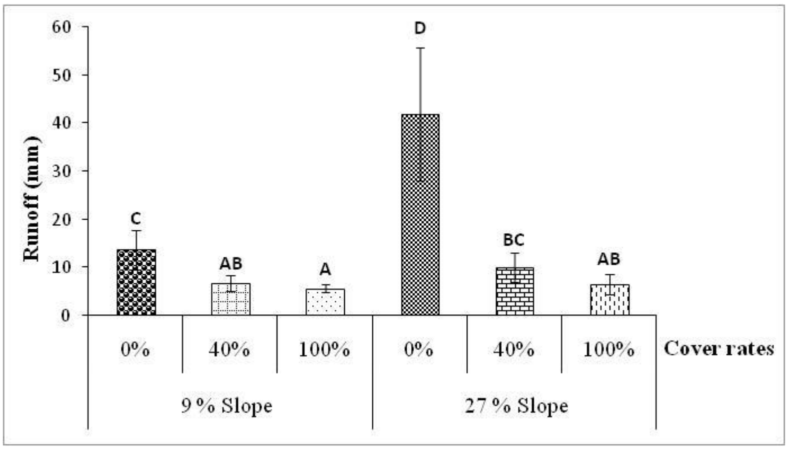

Figure 1 : Effect of cover rates on total annual runoff on a 9 % and 27 % slope in Lake Alaotra region, Madagascar

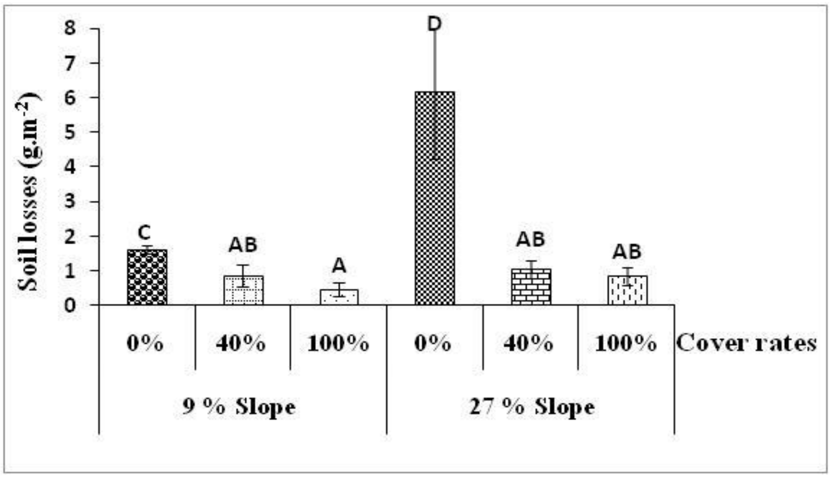

Figure 2 : Effect of cover rates on soil losses on 9% and 27% slope in Lake Alaotra region, Madagascar

Soil moisture

Soil water storage during the rainfall season was significantly increased according to importance of cover crops regardless of the slope (245 mm in cover soil against 200 mm in no cover soil) (Figure 3). This significant difference was not seen between partial and total cover rates. Our results are in agreement with the findings presented by Findeling, 2001. This high water storage could be attributed to the presence of residues, which have high ability to retain moisture and to improve infiltration (Douzet *et al.*, 2010). In addition, it is recognized that surface's residue limits the energy reaching the soil surface, decreasing first stage evaporation of soil water (Scopel *et al*., 2004).

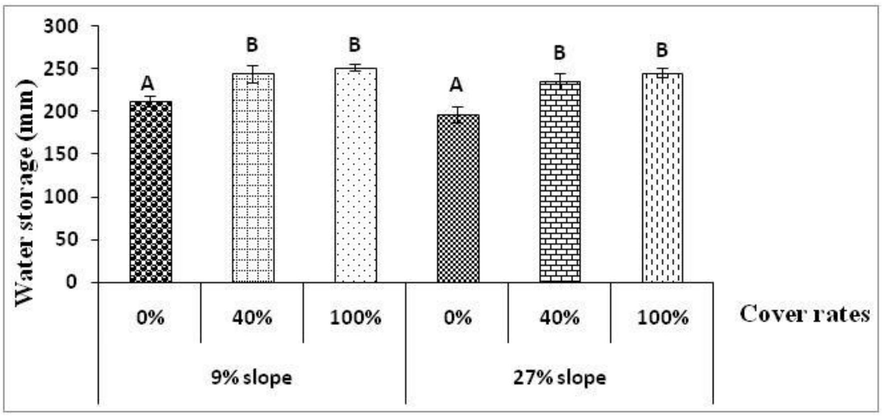

Figure 3 : Mean water storage in the soil on 9% slope and 27% slope and on different cover rates in Lake Alaotra region, Madagascar

CONCLUSION

This study shows that mulch is a key driver in controlling water erosion and improving soil moisture. Runoff and soil losses are negatively correlated with the quantity of mulch to cover the soil, but no significant difference was observed between 40% and 100% cover rates. In addition, positively correlation between water's infiltration into the soil and quantity of crop residues are noticed. However, soil water storage with 40% and 100% cover rates are the same. In fact, partial cover rates (40%) are enough to control water erosion and to improve soil water storage.

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